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14. ABSTRACT

Unmanned Aerial Vehicle (UAV) technology has progressed considerably over the past twenty years. UAVs originally served only in Intelligence, Surveillance and Reconnaissance (ISR) roles, but now routinely conduct strikes in support of commanders' objectives. As UAVs are further integrated into the nation's Joint Air capabilities, many proponents assert that they will soon replace the full spectrum of manned platforms. This would include service in roles such as Air-to-Air superiority, Air-to-Ground strikes, Electronics Warfare (EW), Command and Control, and Sustainment operations. It is essential that proven UAV technology be carefully and methodically integrated into the commander's arsenal of aerial options. This paper identifies critical capabilities and limitations associated with UAVs, along with technical challenges and shortfalls that may or may not be remedied in the near future. Finally, it expands analysis to include options for the JFLCC, and concludes with recommendations for the operational commander.

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UAVs for the Operational Commander: Don't ground MAV (Manned Aerial Vehicles)!

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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04 May 2009

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Abstract

UAVs for the Operational Commander: Don't Ground MAV! (Manned Aerial Vehicles)

Unmanned Aerial Vehicle (UAV) technology has progressed considerably over the past twenty years. UAVs originally served only in Intelligence, Surveillance and Reconnaissance (ISR) roles, but now routinely conduct strikes in support of commanders' objectives. As UAVs are further integrated into the nation's Joint Air capabilities, many proponents assert that they will soon replace the full spectrum of manned platforms. This would include service in roles such as Air-to-Air superiority, Air-to-Ground strikes, Electronics Warfare (EW), Command and Control, and Sustainment operations. It is essential that proven UAV technology be carefully and methodically integrated into the commander's arsenal of aerial options. This paper identifies critical capabilities and limitations associated with UAVs, along with technical challenges and shortfalls that may or may not be remedied in the near future. Finally, it expands analysis to include options for the JFLCC, and concludes with recommendations for the operational commander.

INTRODUCTION

In 2001, Congress requested that the United States Armed Forces develop a fleet of Unmanned Aerial Vehicles (UAVs) to comprise one-third of all deep strike operational platforms.[1] This occurred with the expectation that technology would innovatively progress to allow UAVs to satisfy a wide range of operational missions. The 2006 Quadrennial Defense Review also stated that, "approximately 45 percent of the future long-range strike force will be unmanned."[2] Military history has proven that a haphazard approach to integration of new technology occurs with disastrous effects. A recent example of overreliance on technology, as applied to fixed wing aircraft, occurred in the Vietnam War when confidence in air-to-air missiles resulted in a lack of pilot air-to-air training and omission of a gun on the original F-4 Phantom. When losses mounted, the United States went "back to the basics" and integrated training programs and proven methods to regain desired kill ratios.[3] UAV technology has tempted commanders to integrate unproven platforms into the operational environment. Following the September 11th attacks and ensuing Global War on Terror (GWOT) operations, the Predator and Global Hawk UAVs were placed into service prior to completion of required operational milestones.[4] Fortunately, the action resulted in largely successful results.[5]

Over the past twenty years, UAVs have evolved to provide operational commanders with valuable tools at their disposal. Primarily designed for Intelligence, Surveillance and Reconnaissance (ISR) missions, an RQ-1 Predator UAV fired a Hellfire missile at an enemy

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[1] O'Rourke, Ronald. *Unmanned Vehicles for U.S. Naval Forces: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2006), 1.
[2] --. *Quadrennial Defense Review Report.* (Washington, DC: Office of the Secretary of Defense, 2006), 46.
[3] Elward, Brad. *U.S. Navy F-4 Phantom II MiG Killers 1965-1970.*(Osprey Publishing, 2001) ,6.
[4] Bone, Elizabeth. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 9-10.
[5] Ibid.

target in 2001, proving that smart weapons could be effectively employed from unmanned platforms in real-time operations. Shortly after, the multi-mission Predator was redesignated the MQ-1.[6] This strengthened arguments of defense analysts who had previously claimed that, within years, UAVs would effectively replace manned aircraft across the full spectrum of strategic and operational aerial warfare, most notably as newly designed Unmanned Combat Aerial Vehicles (UCAVs).[7] From their original designs as ISR platforms, UAVs would soon potentially serve the commander in operational functions such as Command and Control, [Force] Protection, Sustainment and Fires.

This paper intends to prove that an overreliance on fixed-wing UAVs and UCAVs, employed by commanders for numerous Operational Functions, will produce a high-risk environment where promised technology does not deliver the desired results. Instead, military leaders should smartly and methodically integrate multi-roled UAVs with a complement of manned platforms, ultimately providing the commander with a portfolio of options for effective fighting in future joint theaters.

BACKGROUND

Before manned flight, Unmanned Vehicles (UVs) were utilized as a means to project fires upon the enemy. As early as the American Civil War, balloons equipped with explosive charges were launched towards enemy lines in hopes of inflicting losses.[8] "UAVs were tested during World War I, but were not used in combat by the United States during that war."[9] The battles of World War II witnessed fixed-wing UV utilization by the Germans,

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[6] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), 4.
[7] Centner, Christopher M. "Consigning air bases to the dustbin of history." *Airpower Journal.* (No. 12, Spring 1998), 100.
[8] Goldfinger, Jeffrey. "The Pilotless Eye in the Sky." *The Hook: Journal of Carrier Aviation.* Summer 2002, 34.
[9] Bone, Elizabeth. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2003), 2.

when upwards of 10,000 V-1 flying bombs were launched at British cities.[10] The first use of UAVs in combat by the United States occurred in 1944, when TDR-1 TV-guided drones were "piloted" against Japanese ground positions in the Pacific theater.[11] UVs eventually evolved from unguided projectiles to programmed platforms, and the advent of computers and advanced datalink technology allowed UAVs to be controlled through the entire flight duration. From takeoff to landing, fixed-wing UAVs were "piloted" by ground controllers, and served in critical ISR roles during Operation DESERT STORM.[12]

The United States military currently utilizes several primary UAV platforms, providing functions from the tactical to strategic levels of command. RQ-5A/MQ-5B Hunter, RQ-7A/B Shadow 200 and RQ-8A/B Fire Scout Army UAV platforms provide ISR and limited strike capability (MQ-5B) to ground tactical units, eliminating the need for squadrons of aircraft, numerous maintenance personnel, airfield infrastructure and trained pilots.[13] The advantages of these capabilities cannot and should not be understated, as these platforms provide an around-the-clock, in-theater presence that is not readily and inexpensively granted by manned fixed or rotary-wing platforms.[14] The RQ-1/MQ-1 Predator UAV, capable of operating from smaller runways, easily allows more than 24 hours of on-station time with sensors that provide significant intelligence services and limited strikes to the operational commander.[15] Finally, the RQ-4 Global Hawk High Altitude Endurance (HAE) UAV, comparable in size to a Boeing 737 airliner, is considered a strategic asset and can be sent on ISR missions more than 5,400 miles away from its launch site,

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[10] Ibid.
[11] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), K-1.
[12] Geer, Harlan, *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 2.
[13] Ibid.
[14] Ibid.
[15] Ibid.

subsequently loiter at 60,000 feet for 24 hours, and then return to base.[16] Controlled via Line of Sight (LOS) satellite communications, Predator and Global Hawk platforms routinely operate thousands of miles away from the safety of ground control stations.[17]

In Operation ENDURING FREEDOM in 2001, UAV technology evolved with employment of an AGM-114 Hellfire missile from a Predator against a stationary ground target, providing the first UAV fires for the operational commander.[18] Ground controllers were able to find, identify and prosecute a target without having to commit actual U.S. forces in theater. In Iraq in 2003, a Predator launched a Stinger heat-seeking missile at an airborne MiG-25 Foxbat before the Iraqi fighter subsequently employed its own weapons, destroying the unmanned drone. This first UAV air-to-air engagement prompted many to believe that unmanned platforms would soon provide commanders with all the capabilities of manned aircraft.[19] Some analysts proclaimed that "missions currently undertaken by manned aircraft could be turned over to unmanned aerial platforms" in the near future, and forced some in Congress to believe that they "may have to contemplate the replacement of a significant portion of the manned aircraft fleet with unmanned aircraft that have yet to be designed."[20]

DISCUSSION / ANALYSIS

Primary missions of UAVs are best summarized as those deemed too "dull, dirty or dangerous" for manned platforms.[21] Overwatch in the Iraqi and Afghan counterinsurgency

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[16] Geer, Harlan. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 44-45.
[17] Ibid.
[18] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), 4.
[19] Bone, Elizabeth. *Unmanned Aerial Vehicles: Background and Issues for Congress*. (Washington DC: Congressional Research Service, 2003), 16-17.
[20] Geer, Harlan. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 3.
[21] Ratnam, Gopal. "UAVs Vs. Manned Aircraft? New Road Map Sees Larger Roles for Robot Planes" in *DefenseNews.* (15 August 2005)

environments, one of the most undesirable missions for many manned squadrons, is a predominant "dull" mission for the Predator.[22] Initially unarmed, the Predator now routinely carries Hellfire air-to-ground missiles on missions that may result in targeting opportunities for the operational commander.[23] UAV platforms are also able to fly in theaters where commanders would be unwilling to send American pilots, allowing conduct of "dirty" missions in theaters possibly contaminated by varying types of Weapons of Mass Destruction (WMD).[24] Additionally, unmanned platforms can be utilized in high-threat environments, made "dangerous" by surface-to-air missiles (SAMs) or other threats.[25] An analysis of advantages and disadvantages of unmanned versus manned technology will help decide the future role of UAVs in the warfighting environment. One must consider capabilities and limitations, along with potential innovations and technological advancements. Although UAV discussions may be expanded to include satellites and cruise missiles, only unmanned and manned fixed-wing vehicles will be included in the following analysis, and will focus on missions of fixed-wing platforms at the operational level of war.[26]

One of the most important subjects of debate is survivability of platforms in adverse environments. In recent history, mishap rates of UAVs soared as high as one hundred times that of manned vehicles.[27] These numbers, in an era of decreasing budgets, scaled-down procurement and comparable price tags, are unacceptable by any standard. In the ten-year period from 1994 to 2003, more than one-third of the Predator operating fleet was lost in

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[22] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), 2.
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Ibid.
[27] Ibid.

various mishaps.[28] In the early days of Operation ENDURING FREEDOM, one of only two Global Hawk UAVs was lost to a mishap, costing the operational commander one-half of his current theater assets.[29] Although the original RQ-1 Predator's cost was only one-fifth that of an Air Force F-16C, the commander now must view today's advanced UAV platforms as "'aircraft' versus airframes that may be treated as expendable or attritable equipment," and historically high mishap rates that impact numbers of platforms available for operational functions cannot be tolerated.[30] Previously considered expendable, UAVs are now equipped with sensors, weapons suites and equipment that force attrition and compromise to become factors when comparing unmanned and manned technology.[31] With mission "creep" and increasing acquisition costs prevalent between both types of platforms, high-tech UAVs such as the Global Hawk became as expensive as its comparable manned platform, the U-2.[32] Even today, "the per-unit and per-pound development and procurement costs of medium and large unmanned vehicles are similar to the costs associated with manned vehicles."[33] Combined with costs of ground stations and communications relays, one must question whether UAVs will actually be more cost-effective over time than their manned counterparts.

UAVs must also overcome significant hurdles regarding all-weather capability. Runway takeoffs and landings, routine events for manned platforms, remain one of the most dangerous times for unmanned fixed-wing platforms, and designers hope to reduce mishaps caused in this flight regime by automating these evolutions and removing ground personnel

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[28] Bone, Elizabeth. *Unmanned Aerial Vehicles: Background and Issues of Congress.* (Washington, DC: Congressional Research Service, 2003), 22.
[29] Rivers, Brendan P. "Global Hawk Down" *The Journal of Electronic Defense.* February 2002, 27.
[30] --. *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.* (2005), 17.
[31] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), D-8.
[32] Geer, Harlan. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 9-10.
[33] Ibid.

from the process.[34] Since UAVs also rely on continuous Line of Sight (LOS) datalink communications to properly function, platforms have often been lost as a result of varying weather conditions.[35] Unless reacquired within a short period, the platform proceeds unguided on autopilot, and may continue out of range or be unable to reacquire its signal. This vulnerability was so pronounced during Operational ALLIED FORCE, that Hunter UAVs were "sent home each year from the Balkans [before] the winter weather season."[36] In contrast, manned aircraft routinely operate in adverse weather conditions that preclude effective use of unmanned platforms.

Command and Control of warfighting assets is an operational function imperative for the commander. A scarcity of bandwidth or lack of datalink connectivity adversely affects the overall functionality of unmanned assets in a dynamic environment where Line of Sight (LOS) communications must also be maintained. Flight control of advanced UAVs and "transmitting [of] video data from distributed platforms requires megabytes of bandwidth, not kilobytes," and these numbers will grow rapidly in coming years of accelerated UAV production.[37] Expanding roles will bring more unmanned platforms into a single theater, "and the resulting competition for existing bandwidth may render the expansion of UAV applications infeasible and leave many platforms grounded."[38] An analysis of UAV use in the Global War of Terror (GWOT) highlighted the fact that "the limited number of

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[34] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), 69-70.
[35] Bone, Elizabeth. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2003), 24.
[36] Ibid.
[37] Gottfried, LCDR Russell. *Unmanned Vehicle Distributed Sensor Management and Information Exchange Demonstration.* (Monterey, CA: Naval Postgraduate School, 2004), 11-12.
[38] Geer, Harlan. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 21-22.

frequencies available often restricted the number to one UA[V] airborne at a time."[39] Absent high levels of available bandwidth and uninterrupted datalink transmissions, UAVs degrade to fly autonomously, orbiting until communications are regained or until running out of powerplant fuel.[40] Some platforms automatically return to base, but will do so prior to completion of the mission.[41] Each of these options proves unacceptable in high-threat, multi-roled environments against peer adversaries where the factor of time is critical for success. Enemy forces will further compound the problem through denial, disruption, jamming or spoofing of datalink communications, Global Positioning Systems coverage and satellite transmissions, actions that potentially force aborts of critical missions.[42] Manned aircraft, requiring no datalink support and degrading to backup navigation, adjust in this Electronic Warfare (EW) environment to continue on the operational mission.

Flexibility and versatility are essential characteristics of air platforms needed by the operational commander. Unmanned vehicles must overcome several hurdles to demonstrate this capacity. Most UAV platforms must be preprogrammed for a route of flight, and changes to this profile demand time and bandwidth from the associated ground station.[43] While potentially fixed by advances in technology, UAVs must also be able to expeditiously transit across the Joint Operating Area (JOA) for retasking in support of the commander's objectives. With maximum speeds under 120 knots, today's armed reconnaissance UAVs require excessive time for transit to new areas of operational tasking.[44] To correct this issue, operational UAVs will require a much larger powerplant and its accompanying fuel.

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[39] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), 68.
[40] --. *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.* (2005), 9.
[41] Ibid.
[42] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), K-3.
[43] Ibid.
[44] Ibid.

Incorporation adversely affects operating weight, combat radius and loiter times, which are currently advantages of UAVs over modern manned platforms.[45] With manned aircraft shifting to new tasking at much greater airspeeds, lighter and smaller UAVs are currently unable to compete. Procurement of more theater UVs is the only alternative to new and costlier designs that will satisfy operational requirements.

As next-generation UAVs are designed for expanding roles and responsibilities, they must carry larger weapons suites and more sensors. This will contribute to the requirement for a larger powerplant, as mentioned above. Attempts to maintain a smaller airframe and lower radar cross-section, without compromising loiter time, will necessitate in-flight refueling capabilities.[46] Vast research continues for the advancement of UAV technology, and one of the most difficult tasks encountered by design teams involves in-flight refueling. Thus far, these teams have been unable to successfully design, test and implement control mechanisms that reliably complete coordinated tasks of the in-flight refueling evolution.[47] Several factors must be considered. Multiple platforms must be capable of simultaneously executing rendezvous on tanking platforms at a specified time, with minimal delay.[48] Additionally, unmanned platforms must exercise deconfliction from one another and manned aircraft, a task that has proven difficult to meet.[49] Once joined, the UAV must also be able to routinely make and maintain contact in a safe and successful manner with the refueling platform.[50] In an era of rising costs and more complex platforms, the margin for error will be

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[45] --. *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.* (2005), 11.
[46] Ibid.
[47] Hinchman, Jacob. *Automated Aerial Refueling Presentation to 2007 ARSAG Conference.* (Wright-Patterson AFB, OH: Air Vehicles Directorate), 16-17.
[48] Ibid.
[49] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), F-5.
[50] Hinchman, Jacob. *Automated Aerial Refueling Presentation to 2007 ARSAG Conference.* (Wright-Patterson AFB, OH: Air Vehicles Directorate), 16-17

pushed lower than ever. Manned aircraft, in all types of day and night weather, routinely conduct this evolution, and the previously mentioned UAV control limitations must be overcome in order for platforms to be fully integrated for operations.[51] For the foreseeable future, UAV platforms must carry adequate fuel quantities for the entire mission in theater, with in-flight refueling options unavailable.

Operational commanders must achieve air superiority early in any conflict to facilitate follow-on objectives, and competitive air platforms should demonstrate full capacity in both air-to-air and air-to-ground missions. Fourth-generation platforms such as F-15s, F-16s and F-18s have demonstrated multi-role capability and proficiency in the Self Escorted Strike (SES) roles, yet unmanned vehicles fail to display adequate progress on this front. As previously mentioned, proponents of UCAVs argue that the Predator's 2003 Stinger missile shot against an Iraqi MiG-25 Foxbat highlights initial capability in the air-to-air arena.[52] They may neglect, however, to mention that the second-generation fighter immediately downed the drone, and that UAV's missile failed to track and kill its target.[53] This engagement, conducted in the infancy of multi-role UCAV design, demonstrates glaring needs of unmanned platforms that require immediate attention in the near-term future. As noted in discussions regarding deconfliction required for large-scale in-flight refueling, UAVs have not demonstrated ability to operate in close proximity with manned platforms.[54] This limitation currently precludes UAV operations in most domestic and international airspace, and the Federal Aviation Administration (FAA) struggles to find solutions to the

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[51] Ibid.

[52] Bone, Elizabeth. *Unmanned Aerial Vehicles: Background and Issues for Congress*. (Washington DC: Congressional Research Service, 2003), 16-17.

[53] Ibid.

[54] --. *Unmanned Aircraft Systems Roadmap, 2005-2030*. (Washington, DC: Office of the Secretary of Defense, 2005), F-5.

spectrum of limitations posed by datalink and bandwidth reliability, airspace deconfliction, all-weather capability and safety considerations.[55] FAA officials at an industry conference stated, "preliminary proposals spelling how UAVs can be widely integrated into the U.S. airspace were at least seven years away."[56]

Airborne platforms must counter enemy denial of datalink connectivity via EW, fighting through the environment to find, target and destroy airborne targets in the Within Visual Range (WVR) air-to-air arena.[57] Some limitations already present in the air-to-ground environment, such as two-dimensional displays and the "soda straw effect" of sensors, could severely limit the commander's ability to employ UCAVs in air-to-air roles.[58] While designs of future UCAVs will likely physically outperform manned vehicles, sustaining high "G" forces and demonstrating tighter turn capability than their counterpart, the crux of a successful dogfight is the ability to quickly find an adversary in a three-dimensional, panoramic field, then effectively maneuver to a position from which one can employ weapons. Even if technology existed that could process and display this enormous amount of data for a ground controller, the question persists: Could a single controller, or possibly a larger team of required controllers utilizing flawless crew coordination, process the data and effectively maneuver the platform? "Aerial combat is often described as the most challenging mission for manned aircraft to perform," and operational commanders must proceed with caution when considering employment of UAV teams as the sole providers of air superiority or supremacy.[59]

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[55] Pasztor, Andy. "Unmanned Aircraft Face Hurdles" in *Wall Street Journal.* (July 1, 2008), B5.
[56] Ibid.
[57] --. *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.* (2005), 18.
[58] Geer, Harlan. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 32-33.
[59] Ibid.

Commanders must also consider levels of training and readiness required for employment of UAVs in combat operations. Many analysts assert that replacement of pilots will result in significant cost reductions, yet research demonstrates that "money saved by not having a pilot must be applied to the 'ground cockpit' of the UAV aircrew" at the ground station.[60] Mishaps rates for "pilot-required" UAVs such as the Predator are also markedly lower than those of other UAVs such as the Hunter, Global Hawk or Shadow, which are either autonomously flown or operated by personnel with no aviation background.[61] Although operators do not fly from within the airframe, the layout of the ground console often resembles the cockpit layout seen by airborne pilots.[62] Expanded roles and missions will necessitate more and better-trained personnel, and a team of several personnel may be required for a single UCAV.[63] While advocates of unmanned technology assert that a single controller will successfully "pilot" multiple platforms, studies show that tasks as simple as remote taxiing of a single unmanned platform can challenge experienced operators.[64] Longer missions and extended loiter times will also fatigue ground-based controllers or teams similar to airborne personnel, and the margin for error will be equally slim.

The final and most important factor when considering use of manned versus unmanned platforms, is the intangible "self-deterrent" role that manned aircraft contribute to the decision-making process of leaders and commanders. A retired Marine general, following air operations in Kosovo in 1999, stated, "Normally, the litmus test of going to war was the willingness to suffer casualties in pursuit of [the] objective."[65] UCAV advocates

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[60] Ibid.
[61] Ibid.
[62] Garner, MAJ Mark E. *Human/System Interface (HSI) Issues from a USAF Pilot/Combat Unmanned Air Vehicle (UAV) Test Operator Perspective.* (Wright-Patterson AFB, OH: Air Vehicles Directorate, 2002), 5.
[63] --. *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.* (2005), 18.
[64] Ibid.
[65] Trainor, LGEN Bernard, "Verbatim Special: The Balkan War" in *Air Force Magazine,* (August 1999), 65.

celebrate the ability of unmanned vehicles to operate in high-risk environments without regard for a pilot's safety.[66] Absent the need to worry about downed or captured airmen, planners and leaders may be tempted to send UCAVs into environments where they would never send manned platforms.[67] This is one of the greatest arguments against the use of unmanned platforms across the full spectrum of warfare. While an unmanned strike, air-to-air engagement or reconnaissance mission could occur across enemy borders without immediately risking the lives of servicemen and women, the resulting initiation of hostilities could easily dwarf the benefits enjoyed by the "low risk" unmanned combat vehicles. As leaders and operational commanders ponder actions against adversaries, it remains imperative that they respect the consequences of armed conflict and all of its possibilities. The United States could find itself antagonizing adversaries in multiple theaters, without realizing that many of these transgressions are about to reach a "boiling point." Thus, the self-deterrence inherent in manned flight is one of the most compelling arguments against wholesale introduction of unmanned vehicles into the nation's military.

NAVAL APPLICATIONS: OPTIONS FOR THE JFMCC

The United States Navy currently seeks integration of unmanned platforms into its next generation of fixed-wing aircraft.[68] Although initiated as the Naval variant of UCAS, the X-47 was reassigned as a joint venture with the Air Force X-45 UCAS in December of 2002.[69] The presence of a carrier-based UCAS presents the operational commander with additional options, especially if land-based assets are not in close vicinity to the theater of

[66] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), F-5.
[67] Trainor, LGEN Bernard, "Verbatim Special: The Balkan War" in *Air Force Magazine*, (August 1999), 65.
[68] O'Rourke, Ronald. *Unmanned Vehicles for U.S. Naval Forces: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2006), 2.
[69] Ibid..

operations.[70] This potential integration of UCAVs onto CVNs presents a quiver of options, but needs to overcome technological hurdles, administrative issues and organizational setbacks that have come to the forefront in the past decade, in order to become effective.[71]

Command and Control of Navy UCAVs presents one of the most difficult challenges for the maritime commander. UAV technology is currently limited to Line of Sight (LOS) communications via satellite, a conduit that is unlikely to change for the next generation of vehicles.[72] The Navy now struggles to maintain bandwidth and communications capacity to ably serve as a Joint Maritime Forces Component Commander (JFMCC), and the communications challenges inherent in controlling several dynamic UCAV platforms from hundreds or thousands of miles away are not trivial.

The most significant consideration for the maritime operational commander is safety and sustainability aboard a CVN. Mishap rates for current land-based UAVs, with more restrictive weather and operating limitations, are significantly higher than those of manned aircraft.[73] Manned fixed-wing aircraft routinely recover aboard the CVN in heavy seas, inclement weather and adverse crosswinds. Pilots utilize the SPN-41 and SPN-43 carrier landing systems to fly aircraft to a position from which safe approaches to the landing area can be made.[74] Landing system datalink transmissions are routinely interrupted or dropped, and pilots degrade to altitude and airspeed computations to complete the approach.[75] Once established on final approach, the pilot flies the aircraft via cuing from the Improved Fresnel Lens Optical Landing System (IFLOLS) and voice commands from a trained Landing

[70] Ibid.
[71] Geer, Harlan. *Unmanned Aerial Vehicles: Background and Issues for Congress.* (Washington, DC: Congressional Research Service, 2005), 51-52.
[72] --. *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision.* (2005), 18.
[73] --. *Unmanned Aircraft Systems Roadmap, 2005-2030.* (Washington, DC: Office of the Secretary of Defense, 2005), 53.
[74] --. *CV NATOPS Manual.* (Lakehurst, NJ: Naval Air Systems Command, 2007).
[75] Ibid.

Signals Officer (LSO).[76] Despite best efforts to develop a predictive system capable of calculating ship's movement in higher sea states, such technology is not available.[77] Until research and development produces a safer unmanned alternative, Navy commanders will likely not permit large-scale UCAV operations from carrier flight decks.

Storage and movement of UCAVs on CVN flight decks also present significant problems. Taxi directors currently work hand-in-hand via body signals with pilots to start, taxi, launch, recover and park aircraft on the deck.[78] Studies highlight many gesture recognition difficulties associated with dynamic taxiing, transfer of control from one taxi director to another, and identify "major challenges" such as low light, varying poses, occlusion, director variability and scene clutter which could complicate integration of UCAVs onto the decks of modern aircraft carriers.[79] Maintenance turnaround times do not permit extensive utilization of tow tractors or other devices, and development of low-emissions, fully automated taxiing systems would require a completely revamped CVN platform.[80] Additionally, "dual separate processes for each [manned and unmanned] will not work on the carrier."[81] This consideration presents significant technological hurdles to overcome prior to integrated operation of fixed-wing UCAVs in the CVN environment.

In light of these considerations, one must remember that the U.S. Navy does not currently possess a long-range operational strike platform, capable of organically completing deep interdiction missions.[82] While the JSF will permit a longer range option over the F-18

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[76] Ibid.
[77] Ferrier, Dr. Bernard. *Testing and Evaluation of Landing Aids to Improve UAV/Ship Operational Limits.* (American Helicopter Society, 2007).
[78] --. *CV NATOPS Manual.* (Lakehurst, NJ: Naval Air Systems Command, 2007).
[79] Venetsky, Larry. *Gesture Recognition for UCAV-N Flight Deck Operations.* (Lakehurst, NJ: Naval Air Systems Command, 2003), 4.
[80] Ibid.
[81] Ibid.
[82] --. *Quadrennial Defense Review Report.* (Washington, DC: Office of the Secretary of Defense, 2006), 46.

Hornet and Super Hornet platforms, it is imperative that the Joint UCAV, effectively utilizing fuel consumption, weight reduction and aerodynamic advantages inherent in unmanned platforms, progresses in order to grant the Joint Forces Commander (JFC) the option of deep strikes in enemy territory in the absence of land-based options.[83]

CONCLUSIONS

From analysis, two specific conclusions regarding the application of Unmanned Aerial Vehicle technology are presented. First and foremost, UAVs are not a panacea, nor are they "one-for-one" replacements for manned platforms. History proves that overreliance on unproven technology leads to catastrophic results. Development of an entirely unmanned force, incapable of operating in adverse weather, unable to survive in a dynamic EW environment, and inflexible within a dynamic scenario that demands multi-role options, would handcuff the operational commander. Many significant challenges must be met before UAV technology can be fully integrated into the future spectrum of warfighting.

The counter argument, and the second conclusion of analysis, is that one cannot possibly deny that unmanned technology presents many new opportunities and options to the operational commander, many unattainable with a fleet of manned platforms. These advantages cannot and should not be denied. UAV technology presents the opportunity for vastly increased ISR coverage, improved tactical Close Air Support (CAS), strikes of targets in high-risk areas, and the potential for cheaper and more effective manned and unmanned platforms. However, these innovations should be introduced to the operational environment only as proven technology allows, and should not be haphazardly forced upon commanders or carelessly integrated into the joint airspace as a result of pressures from Congress, defense

[83] Ibid.

analysts or other entities. UAV capabilities will improve with technology, and should be methodically and smartly integrated into the operational environment.

RECOMMENDATIONS

The Secretary of Defense, the Honorable Robert Gates, recently summarized the role of unmanned technology in the theater of operations. The most important aspect of any new technology is supplementing the commander in order to provide a "portfolio of options" from which he can choose.[84] By developing manned and unmanned technologies, the commander with be able to select the platform that is most qualified for the mission, whether piloted by an aviator or "flown" by a ground controller. Ultimately, this "portfolio of options" will risk fewer lives, cost less money and be more flexible than either option alone could provide. Most importantly, expanded capabilities will result in mission accomplishment, allowing achievement of an end state that is most favorable for commanders, the military and the United States of America.

[84] Gates, Secretary Robert M., speech to U.S. Naval War College, 19 April 2009.

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